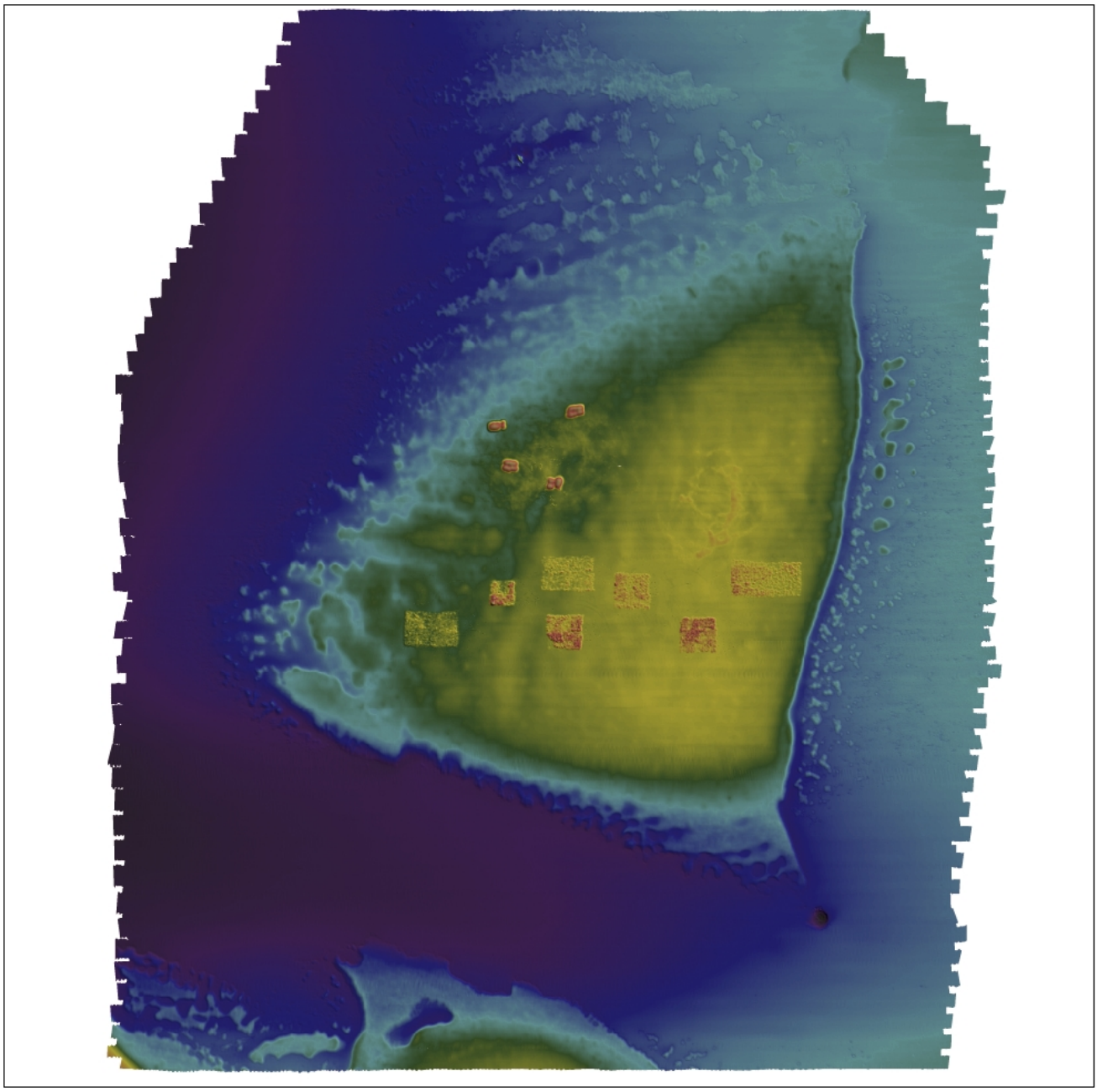
Survey Report:

Cook Point Oyster Sanctuary

Multibeam Sonar Survey

February 2011



NOAA Chesapeake Bay Office

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Summary

We conducted a multibeam sonar survey at Cook Point Oyster Sanctuary in March 2011 to provide as-built bathymetry data and imagery for seven alternative substrate reefs recently constructed by the US Army Corps of Engineers (USACE) Baltimore District. The entire survey extent was 2.9 km^2 (716.6 ac). Additional features mapped were shell mounds and flat plantings created by the MD Department of Natural Resources (MD DNR), reef balls placed by the Chesapeake Bay Foundation, a wrecked WWII era seaplane, and extensive natural oyster shell bottom. Minimum depth of Corps reefs was 3.8 m (12.5 ft; MLLW), and estimated maximum relief was 3.2 m (10.5 ft). The approximate area of alternative substrate reefs ranged from 1,986 to 8,113 m^2 (0.5-2.0 ac). Minimum depth of DNR shell mounds was 4.2 m (13.8 ft). Total area of alternative substrate reefs and shell plantings is 34,722 m^2 (8.6 ac) and 107,695 m^2 (26.6 ac) respectively. A total of 454,929 m^2 (112.4 ac) of un-restored sandy bottom remains on top of the main shoal of the oyster bar, and this is surrounded by 825,384 m^2 (203.9 ac) of natural oyster shell bottom, most of which appears to be highly sedimented.

A compressed (*.rar) version of the GIS data in an ESRI geodatabase can be downloaded from: **ftp://ftp.chesapeakebay.net/NOAA/Ecosystem_Science/Habitat_Assessment/Public/Cook_Point_Multibeam_and_Habitat_Characterization_2011/**

Objectives

In January and February of 2011 the USACE constructed seven alternative substrate reefs on Cook Point Oyster Sanctuary in the Choptank River. In March 2011 the NOAA Chesapeake Bay Office (NCBO) Habitat Assessment Team conducted a multibeam sonar survey of the site to provide as-built bathymetry data and imagery of the constructed reefs. The survey extent was expanded to cover an area that contained reefballs placed by the Chesapeake Bay Foundation, and shell mound reefs created by MD DNR. Because of the complex morphology of natural seabed features in the area, in addition to the amount of apparent natural oyster reef, the survey ultimately was extended to cover the entire central shoal of the Sanctuary.

The survey provides fine scale bathymetric and expanded benthic habitat characterization data that can be used to identify additional sites for restoration and to assess the morphological and surface complexity of differing restoration sites and natural features.

Sanctuary Site Description

Cook Point Sanctuary encompasses a large portion of Cook Point Oyster Bar (Figure 1). The bar includes a geologically isolated shoal between Cook Point (Dorchester County) to the south, and Nelson Point (Talbot County) to the north. The bar also includes shoal areas associated with the Dorchester County shoreline. The centroid coordinates of the sanctuary are 76 ^{o} 16.89’ Lon. and 38° 38.96’ Lat. Prior to the 2011 multibeam survey, parts of the sanctuary were surveyed with sidescan sonar by NOAA Office of Coastal Survey (1999) and the Maryland Geological Survey (MGS; 2007-2010; Figure 2).

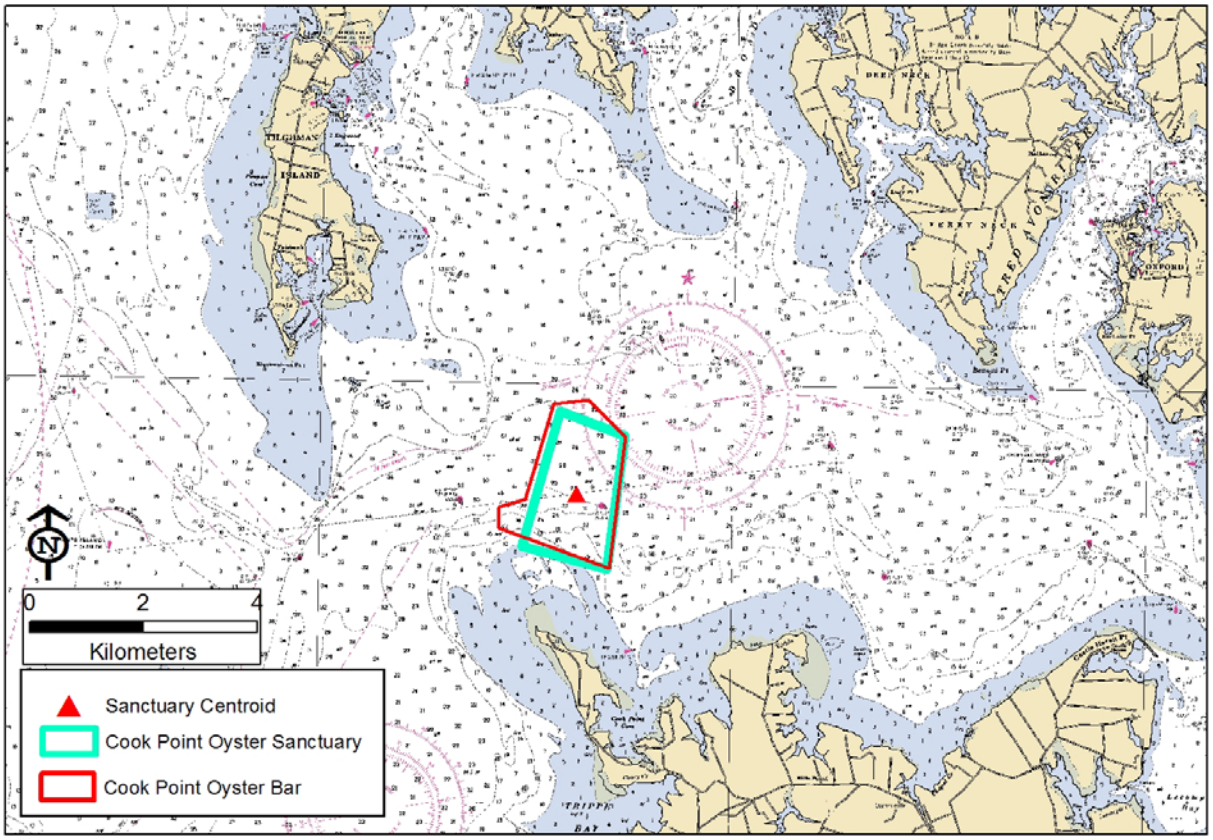

Figure 1. Location of Cook Point Sanctuary and Oyster Bar in the Choptank River.

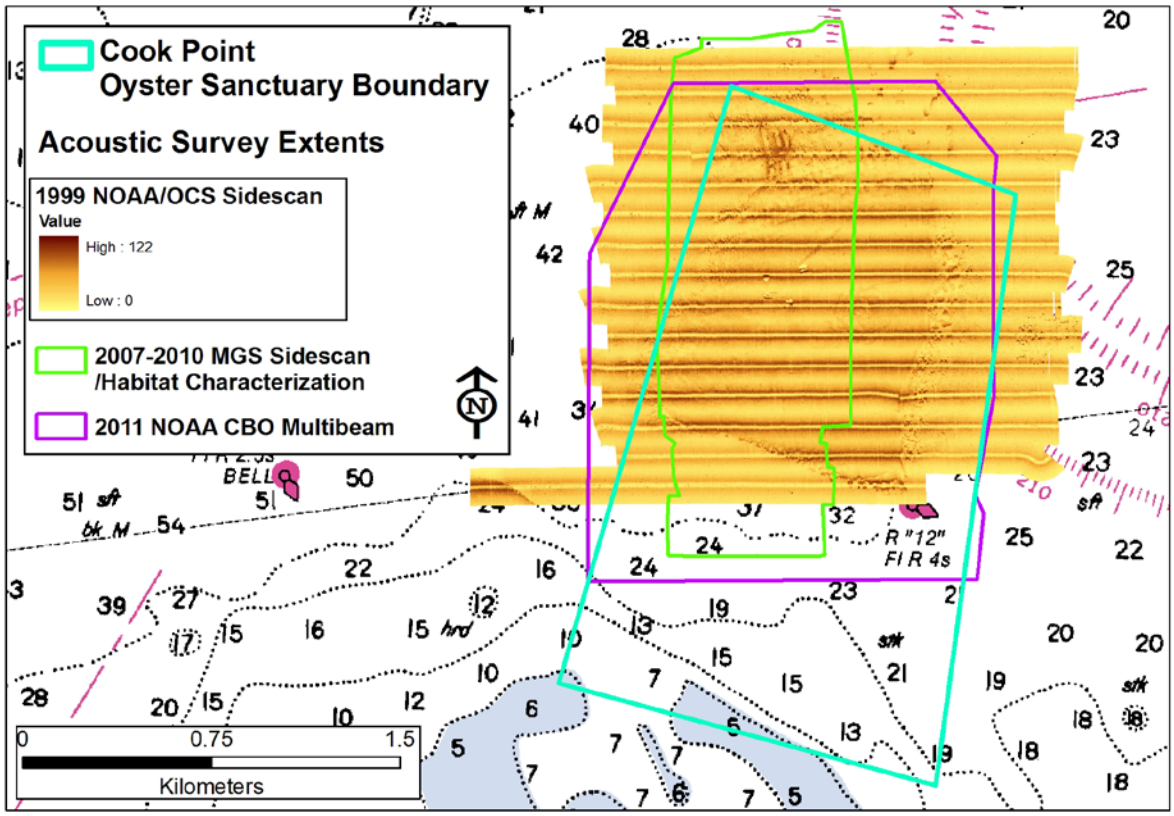

Figure 2. Extents of acoustic surveys conducted at the site. The 2001 multibeam survey expands coverage of the 2007-2010 MGS survey extent and provides an updated and more comprehensive benthic habitat characterization than the 1999 survey.

Methodology

Data Acquisition **-**The NCBO survey vessel, RV Lookdown, is integrated with a complete sensor package to conduct multibeam bathymetric and backscatter surveys. The sonar is a Reson Seabat 8125 multibeam designed to map seabeds less than 100 meters deep. The Seabat 8125 is a 455-kHz system with a 120° swath consisting of 240 individually formed, electronically roll-stabilized 0.5° beams pinging with a maximum rate of 20Hz, depending on water depth. Vessel position and orientation is determined with an Applanix POS/MV Wavemaster V4 (POS). The GPS aided Inertial Motion Unit (IMU) provides measurements of roll, pitch and heading that are all accurate to ± 0.03°. Heave measurements supplied by POS maintain an accuracy of 5% of the measured vertical displacement or ± 5cm for swell periods of 20 seconds or less. The accuracy and stability of measurements delivered by the system remain unaffected by vessel turns, changes of speed, wave-induced motion (sea state dependent), or other dynamic maneuvers. These corrections are provided real-time to the acquisition software and the raw measurements are recorded via Ethernet logging on the acquisition PC. The IMU is located near the vessel's center of motion. An auxiliary Trimble DSM 232 differentially corrected global positioning system (DGPS) provides a ground beacon corrected (RTCM) data stream to the POS. The Seabat 8125 is equipped with a real time sound velocity probe (Teledyne Odom Digibar Pro) at the sonar head that is interfaced with the topside unit to correct for sound velocity variability in the water mass and assist accurate beam-forming. The primary sensor for determining sound velocity throughout the water column is a Seabird Electronics SBE-19 Plus V2 CTD. Sound velocity casts are obtained approximately every four hours during survey operations. Hypack Hysweep 2010 provided the acquisition platform for integrating the sensor data in addition to survey setup and navigation.

Survey Area- 2.9 km^2 of the Cook Point Sanctuary was mapped with multibeam sonar over six days in March 2011. Survey transect spacing was 20 m and there were 103 transects in the survey line plan.

Bathymetry Processing – Bathymetric data were edited with CARIS HIPS processing software. The vessel configuration used for the data conversion was the Lookdown_8125.hvf file. This file includes the preliminary patch test results, the final patch test results, waterline and the Total Propagated Error (TPE) values. All the acquired data was converted and processed in the field. Preliminary data processing consisted of: application of sound velocity, zero tides, and CARIS Combined Uncertainty Bathymetric Editor (CUBE) Bathymetry Associated with Statistical Error (BASE) surface creation. The Hips Subset Editor was the second phase of editing. With the CUBE BASE surfaces of *depth, standard deviation and hypothesis count* identifying areas of outliers, Subset editing was used to remove gross outlier soundings while identifying potential tidal and motion artifacts. The verification and alignment of features from adjacent lines also confirmed preliminary sensor offsets. CUBE BASE surfaces were created to illustrate adequate sonar coverage and to also identify systematic errors or artifacts within the data set. The BASE surfaces created from the merged and TPE calculated soundings are geo-referenced images of a weighted mean surface. The BASE surface uses a combination of range, uncertainty and swath angle weights to assign nodes depth values to create an image of the seabed surface. The BASE surface images were reviewed with multiple resolutions, sun angles, sun azimuths and vertical exaggerations. The BASE surface routine produced images representing *depth, shoal-biased depth, deep-biased depth, mean depth, standard deviation, sounding density, and depth uncertainty*. During acquisition field editing steps were expedited to create BASE surfaces to confirm adequate multibeam coverage for each survey area. Final subset editing of the entire dataset included the re-application of sound velocity profiles, and post patch test refinement from the application of post-processed kinematic data from the POS system. Zone verified tide data were applied to correct for variability in vessel elevation during the survey and to standardize bathymetry data to the Mean Lower Low Water (MLLW) datum.

Backscatter Processing- Hypack Hysweep MBMax software integrated the raw bathymetry (*.hsx) with the raw backscatter (*81x) files and saved the combined data in the general survey format (*gsf). The gsf data files were then loaded into Hypack's implementation of Geocoder, a program that normalizes backscatter data by removing artifacts

inherent in sonar operation. Slope artifacts are removed by loading an edited bathymetric surface from CARIS HIPS into Geocoder prior to processing. The resulting mosaic is saved as a geotiff and in an ASCII XYB text file where the B references the average amplitude intensity at the size of the grid cell.

Ground Truthing and Habitat Characterization- On 10 June 2011 the site was ground truthed with video and Ponar grabs to assist the creation of benthic habitat characterization of the seabed within the sonar survey extent. Georeferenced seabed material descriptions were recorded in real-time as Hypack target files from 13 PONAR grabs and 83 video drops at sixteen generalized sites. Acoustic backscatter mosaics and the ground truthing data were used to identify the geometry and composition of benthic habitat features. Habitat boundary polygons were created and classified with the ArcGIS Habitat Digitizer Extension, using a variant of the Coastal and Marine Ecological Classification Standard-Surface Geology Component (CMECS-SGC) developed for the Chesapeake Bay by NCBO and MGS.

Spatial Data Products - The HIPS export wizard produced a 24-bit sun-illuminated geotiff image of the BASE *depth* surfaces (Title page), and ASCII XYZ text exports at resolutions in accordance with the depth thresholds for the survey. XYZ files were converted to a bathymetric grid standardized to MLLW. The Geocoder export tool produced an acoustic backscatter geotiff image and an ASCII XYB text file. The hillshade, bathymetry, and backscatter grids have a 0.5m grid cell resolution. Video and PONAR point data and habitat characterization polygons are represented as ArcGIS feature class layers. All spatial data were projected to the North American Datum of 1983, Universal Transverse Mercator Zone 18, Northern Hemisphere (NAD83 UTM18N). Bathymetry data use the MLLW vertical datum. Bathymetric data discussed in this document were extracted from the 0.5m grid; reef relief was calculated from range of depth values extracted to create 3D digital elevation models.

GIS-ready data are contained in an ESRI Personal Geodatabase named "Cook Point Oyster Sanctuary Seabed Mapping 2011". A compressed (*.rar) version of the geodatabase can be downloaded from:
ftp://ftp.chesapeakebay.net/NOAA/Ecosystem_Science/Habitat_Assessment/Public/Cook_Point_Multibeam_and_Habitat_Characterization_2011/

Results

Bathymetry – Several bathymetric features related to native oyster restoration projects exist on the top of the main shoal. The most significant features are the seven alternative substrate reefs constructed by USACE (Figure 3, A-G). These reefs (Figures 4-10) were built of 0.08-0.15 m granite pieces (USACE Balt. Dist. 2011). The greatest relief of an individual reef is 3.2 m and was observed on reef A (Figure 4). The most shoal reef sounding is 3.8 m MLLW, located on the southwest corner of reef A. There are also four large (30 x 20 m) mounds of oyster shell (Figure 3, H-K) constructed by MD DNR in 1998. The most shoal sounding is 4.15 m MLLW observed on the southernmost mound (Figure 3, J); the average relief of the four mounds is 2.7 m. Observed circular features are "flat" oyster shell plantings that were placed by MD DNR in 2006 (Figure 3, L) and 1990 (Figure 3, N & O). Both planting sites exhibit detectable bathymetric relief. In the vicinity of L and M (Figure 3) are concrete reefballs placed by the Chesapeake Bay Foundation between 2008 and 2010 (Figure 11). Natural oyster patch reefs are located on the east and west sides of the bar (Figure 3; P, Q, & R); the shoalest (Figure 3, R) is 6.9 m MLLW with a relief of 1.4 m. An additional man-made feature is the charted wreckage of a WWII era seaplane lying among natural oyster patch reefs, on the northern edge of the bar in approximately 9.0 m of water (Figures 12 & 13). This wreck is a popular recreational fishing site.

Charted depths in the final bathymetry grid ranged from 2.8 to 12.1 m MLLW (Figure 14). The shoalest value is the raised left wing of the airplane wreck (Figure 13) and the deepest value is located at the southeastern tip of the main shoal in a depression created by the anchor and chain of the Red #12 navigation buoy.

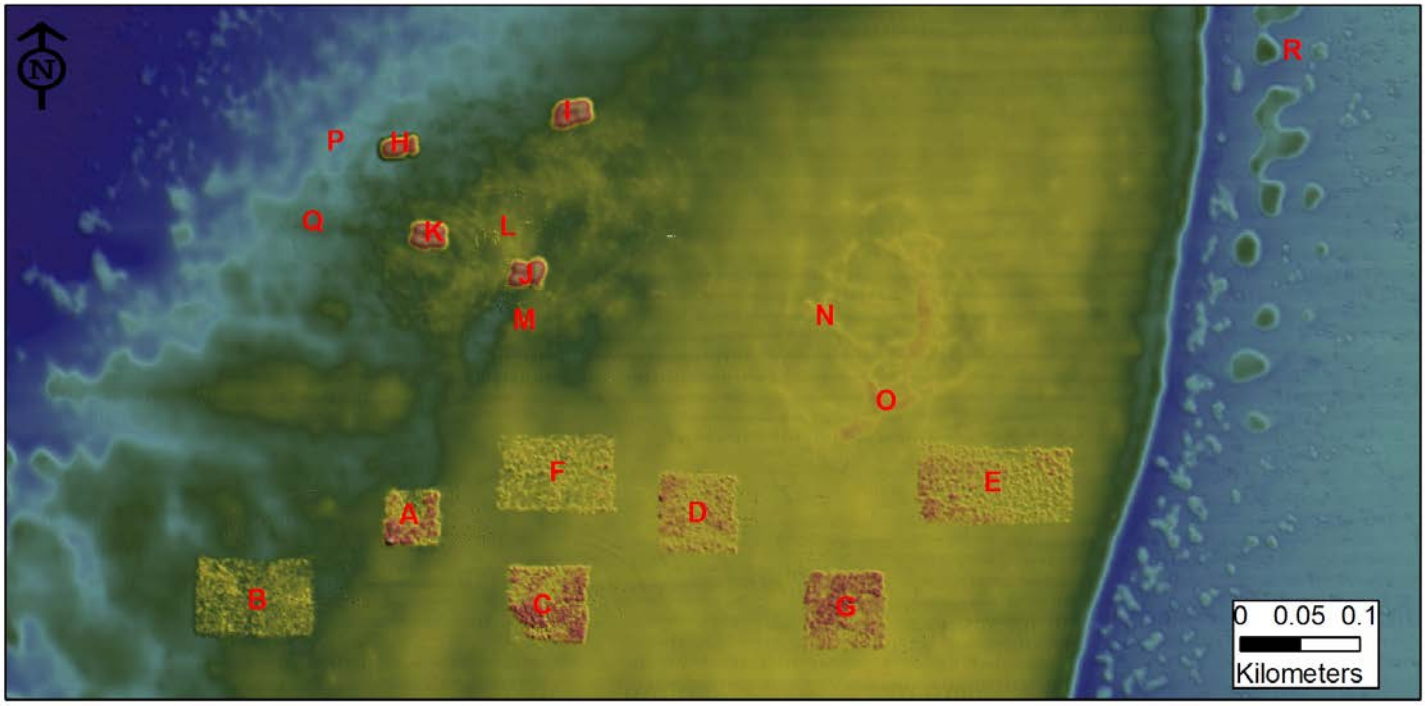

Figure 3. Hill-shaded bathymetry with 3X vertical exaggeration identifying a variety of oyster restoration projects and natural features. Red and blue colors represent the greatest and least depths respectively.

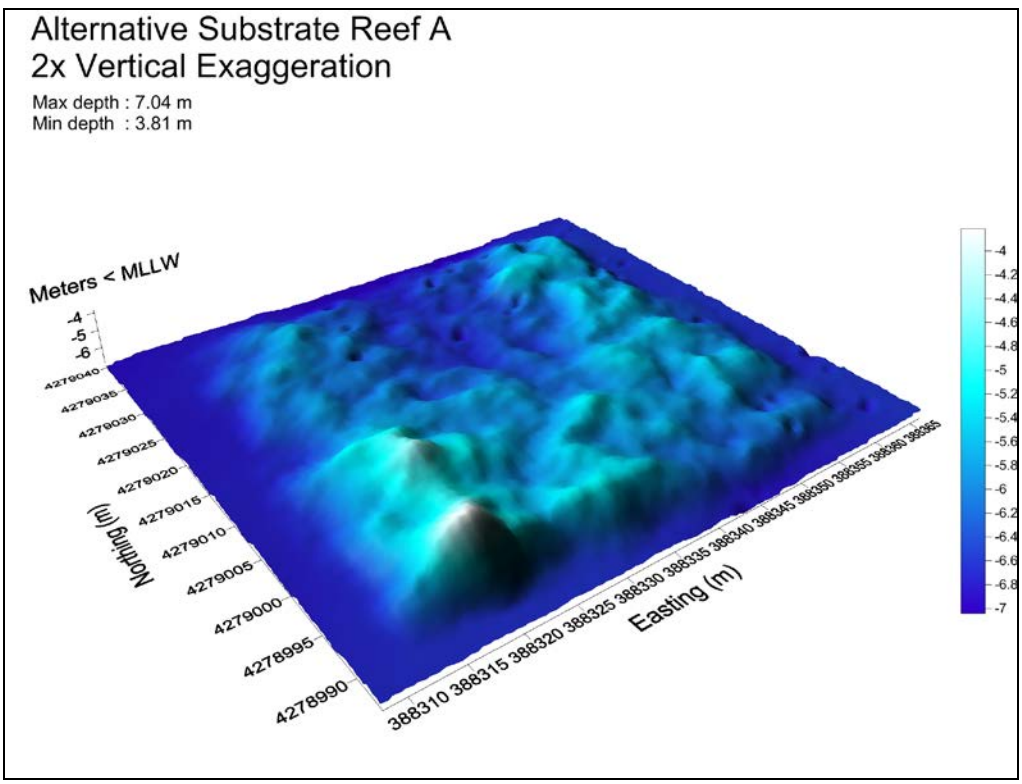

Figure 4. Terrain model of reef A. Circular depressions were created by placement barge spuds.

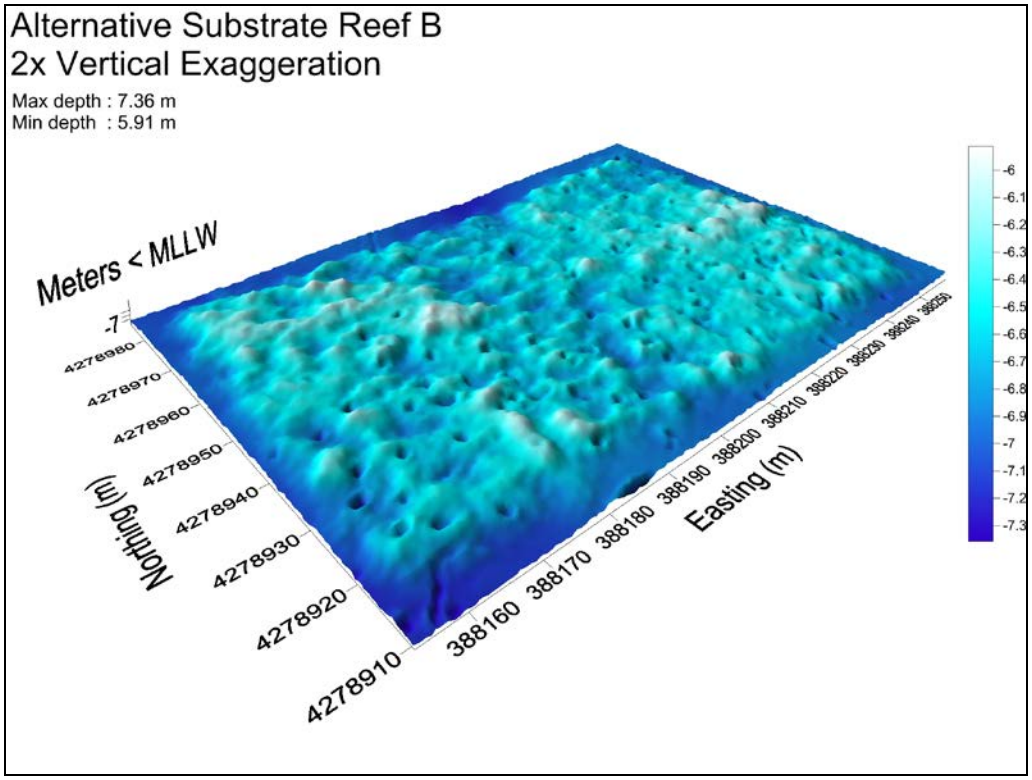

Figure 5. Terrain model of reef B.

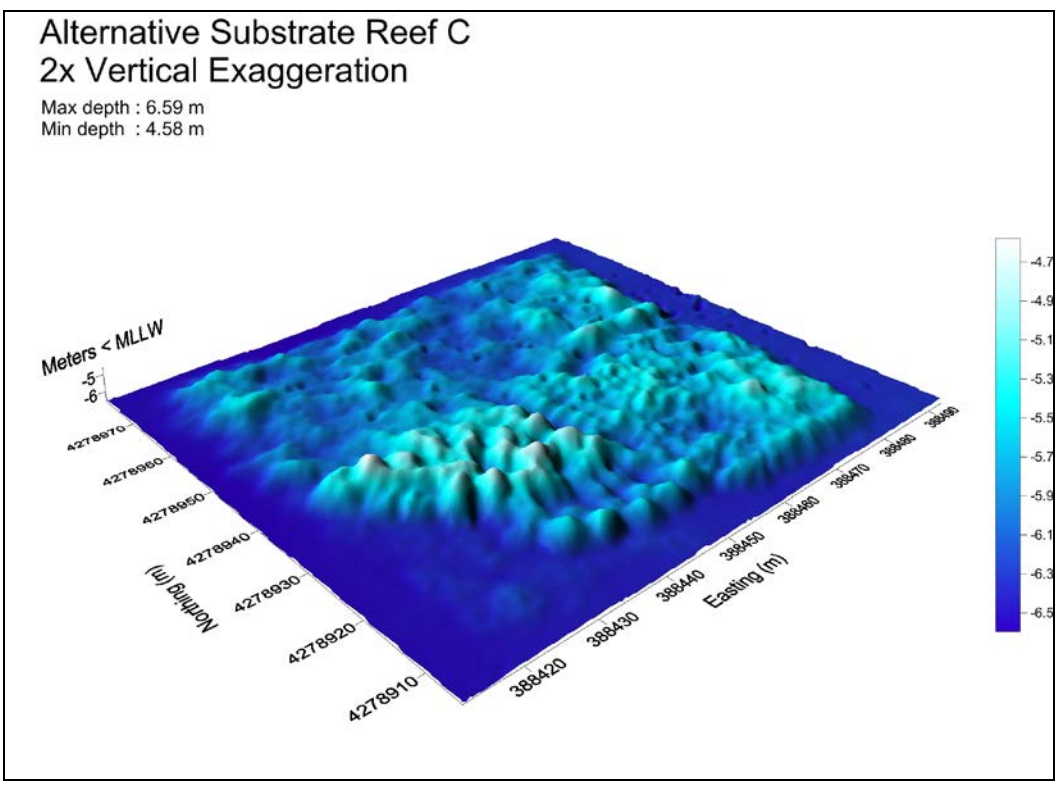

Figure 6. Terrain model of reef C.

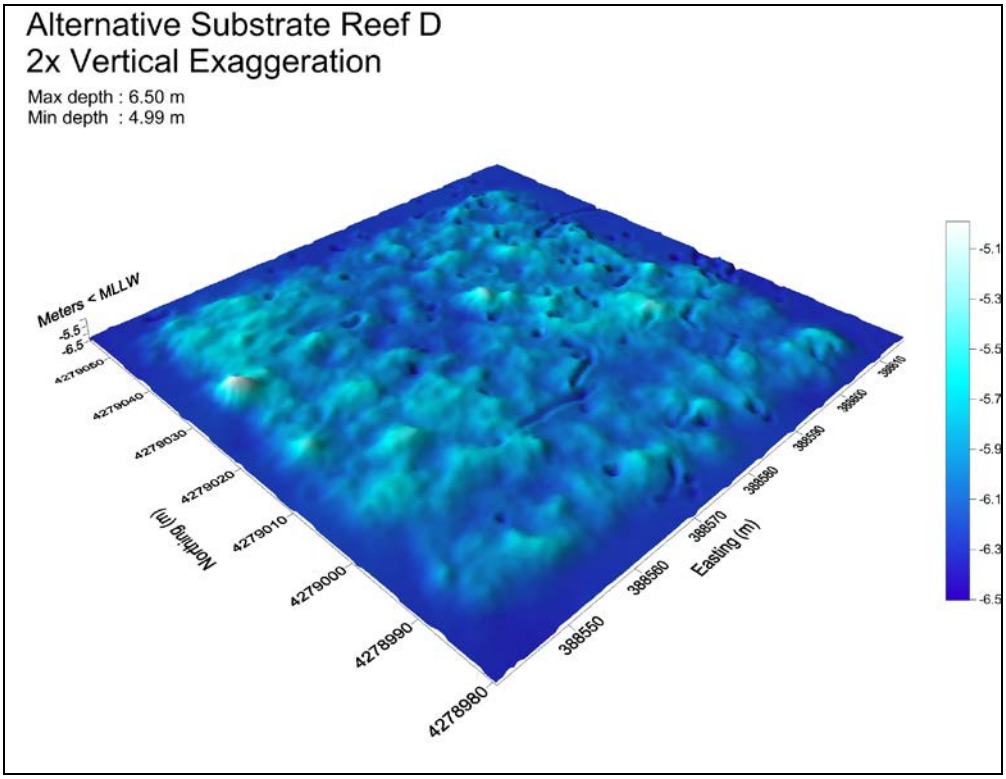

Figure 7. Terrain model of reef D.

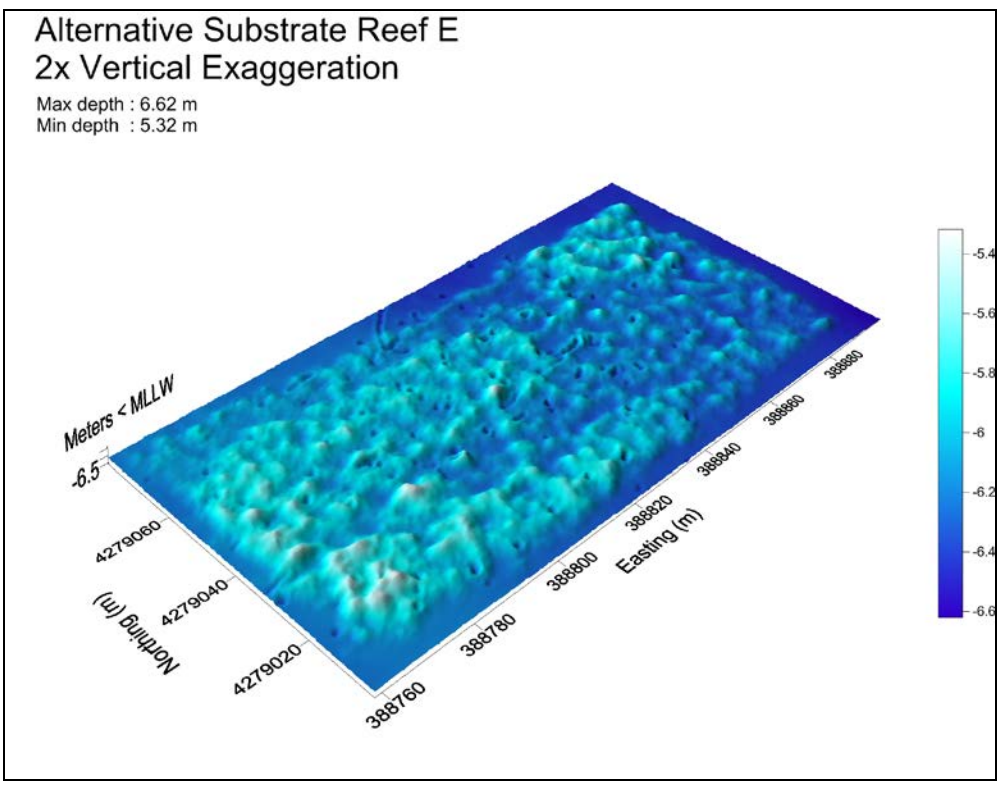

Figure 8. Terrain model of reef E.

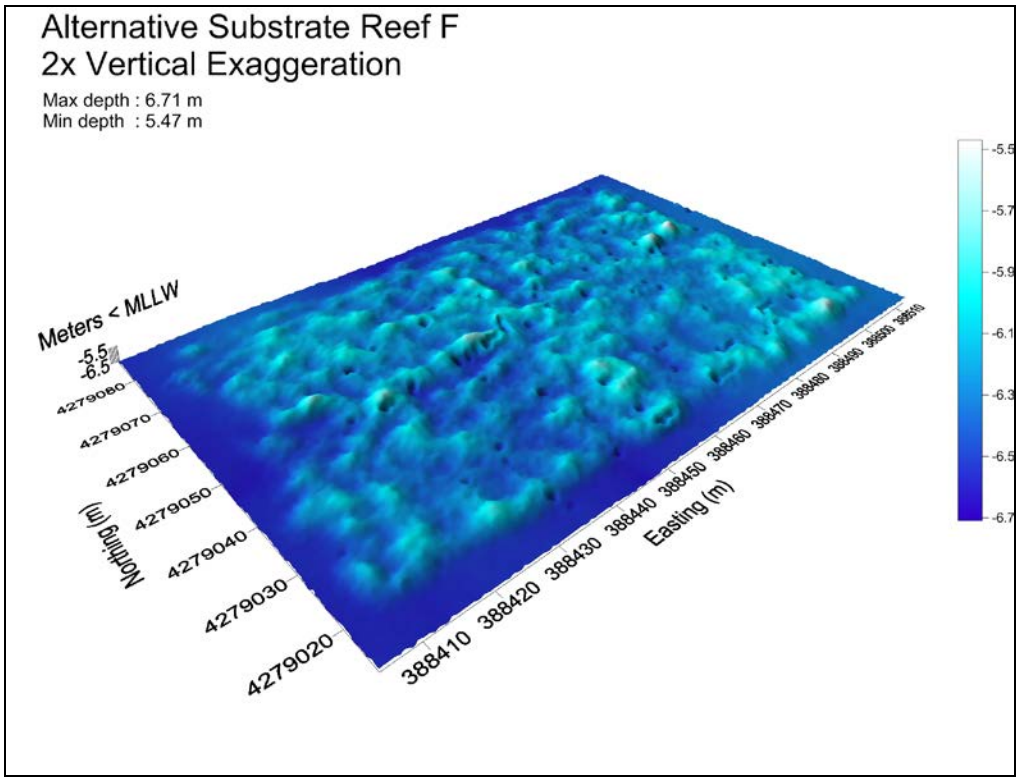

Figure 9. Terrain model of reef F.

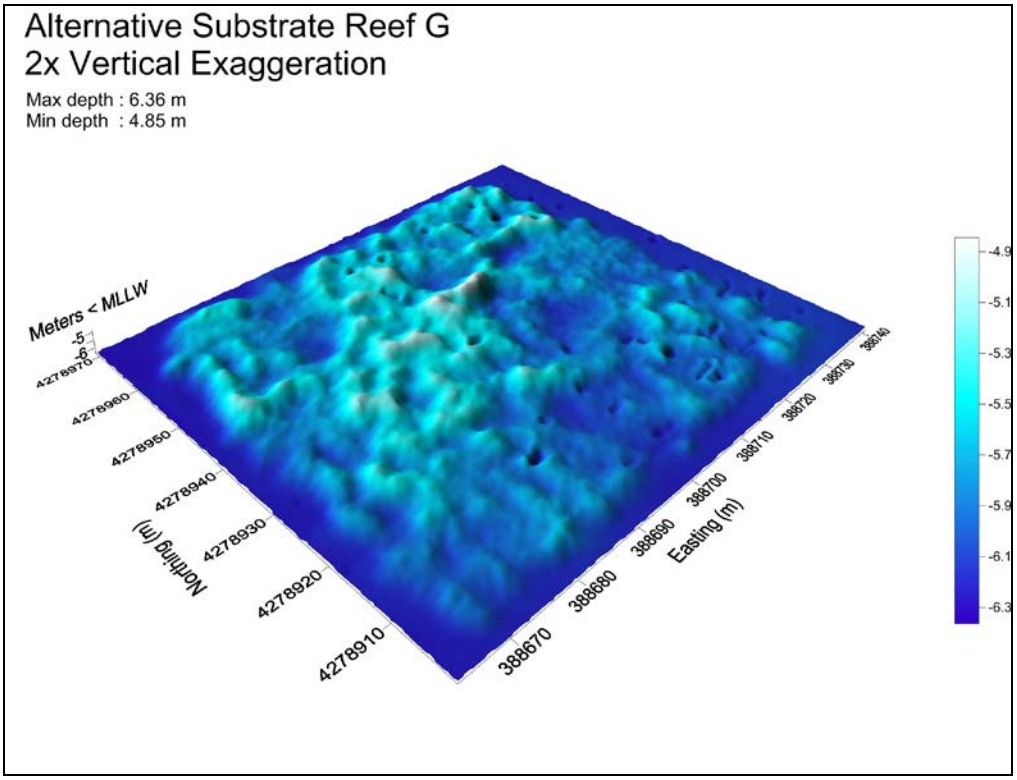

Figure 10. Terrain model of reef G.

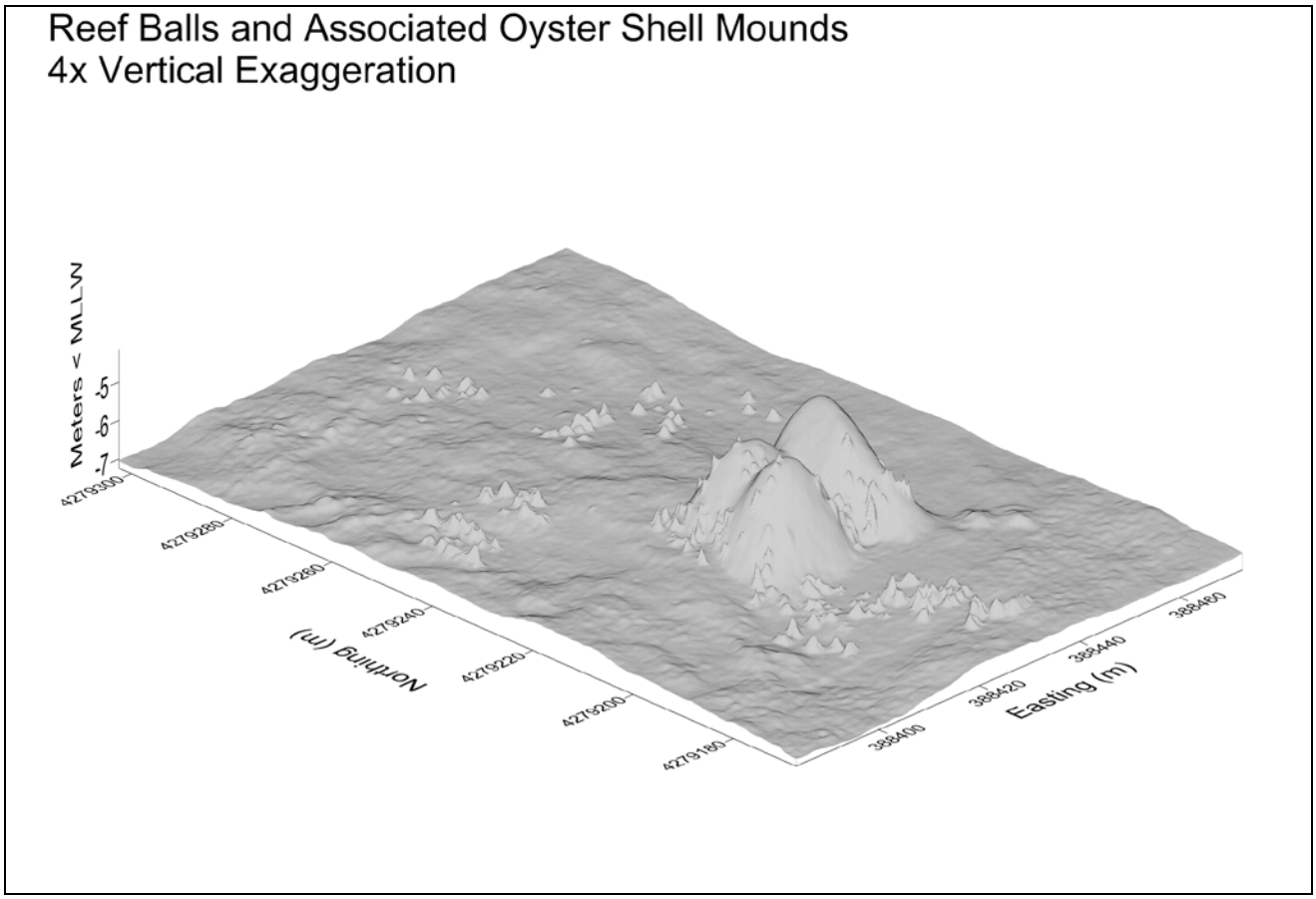

Figure 11. Digital terrain model of reefballs and oyster shell mounds (feature J in Figure 3). Reefballs, the small bathymetric features, were placed on and around the mounds by the Chesapeake Bay Foundation 2008-2010. Shell mounds were constructed by MD DNR in 1998.

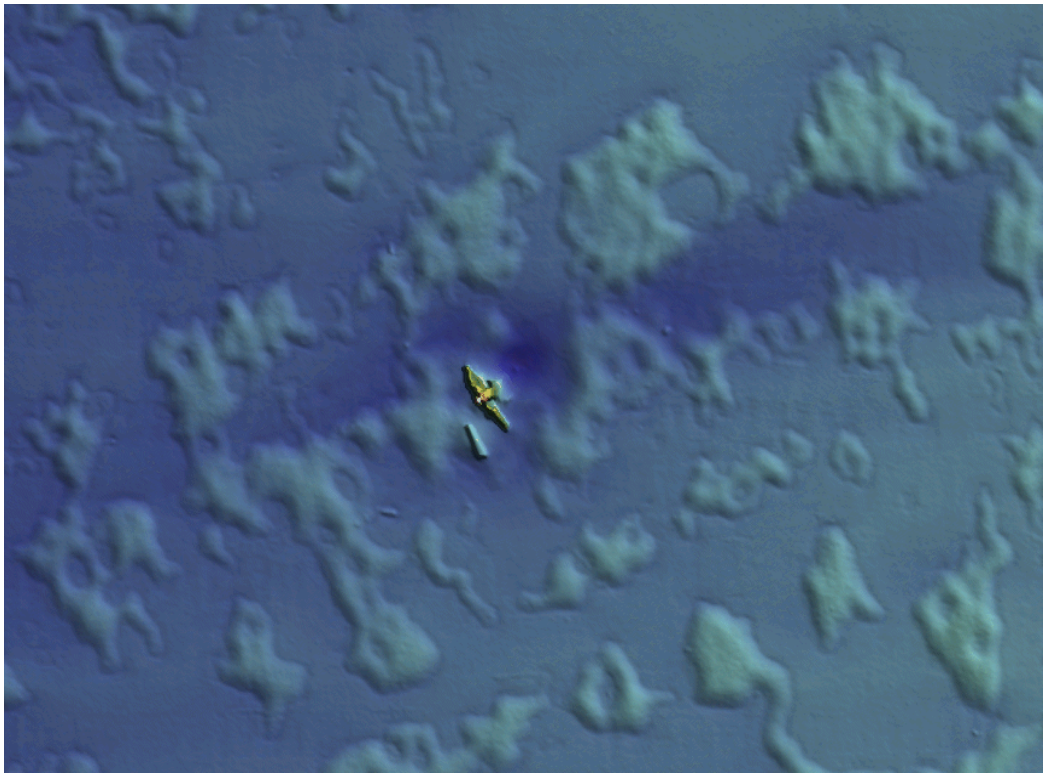

Figure 12. Wreckage of a 1944 seaplane among patch oyster reefs north of the main shoal.

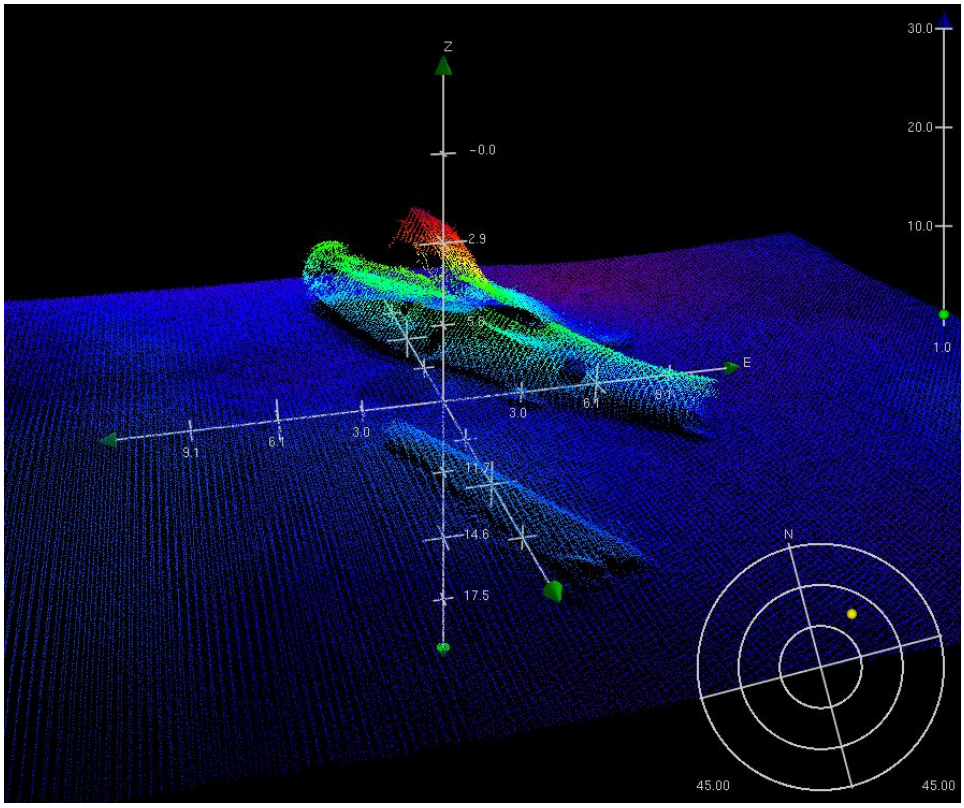

Figure 13. A 3-dimensional point cloud image derived from multibeam sonar echoes provides detail of the wreck. The view is of the left side of the fuselage with the missing tail section on the right. A wing lies in the foreground. The red feature is the remaining stub of the left wing and is the shallowest part of the wreck.

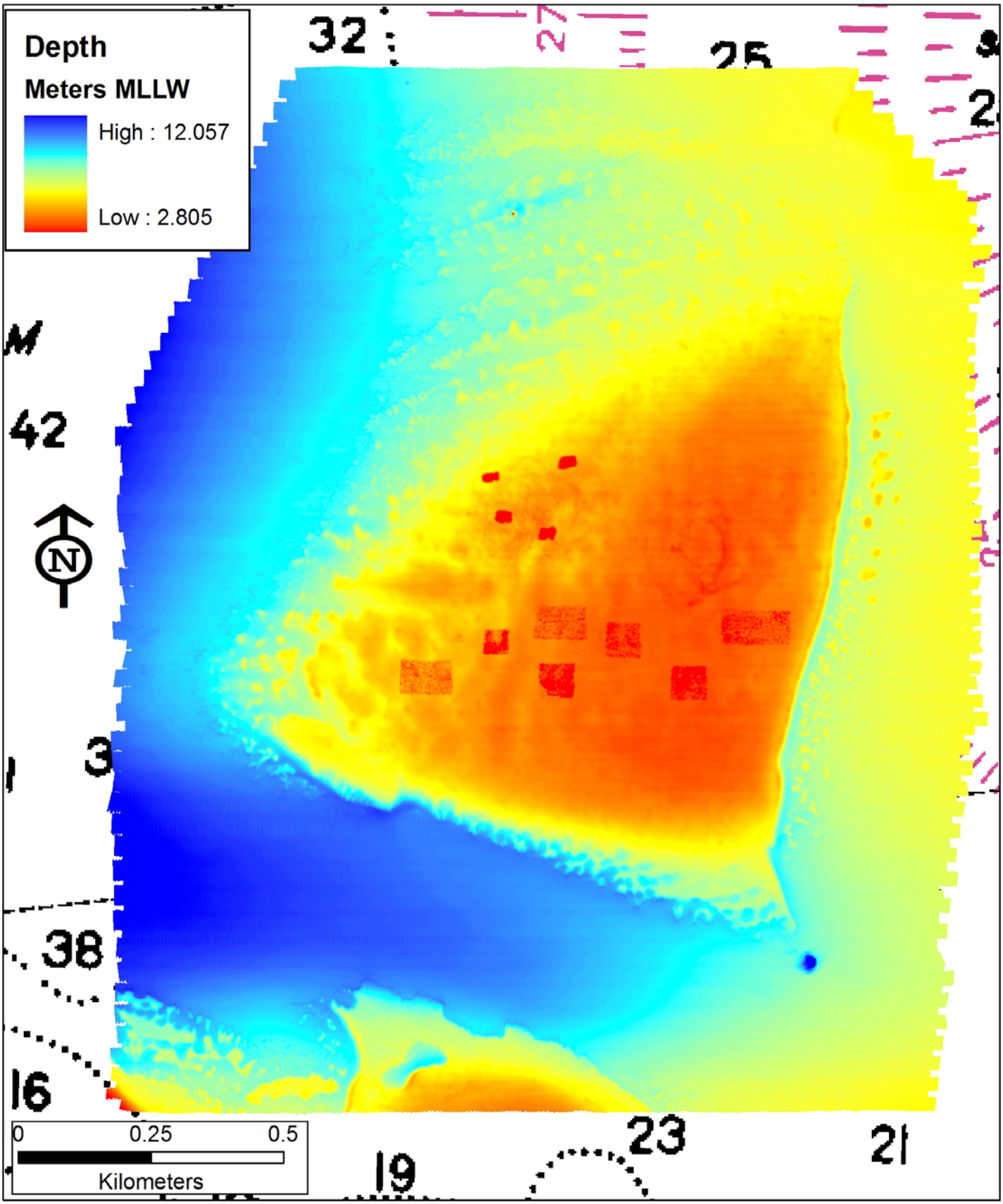

Figure 14. Bathymetry grid of Cook Point oyster bar.

Topographic Complexity- High spatial complexity and surface area can support greater fish species richness (Pittman et al. 2007) and higher numbers of sessile invertebrates per unit of planar area. Using this logic, topographic complexity, as determined from fine scale bathymetry, could be considered a proxy metric for ecological value.

We used bathymetry data to calculate surface area of natural oyster reef and artificial reefs. Bathymetry grid cells (0.25 x 0.25m) were selectively extracted with half-acre polygons. Inconsistent placement of the polygon on the raster image resulted in varying pixel counts so the analysis was normalized for 32490 grid cells. Surface area values were calculated for each cell with a triangulation method (Jenness 2004). Mean surface area was then calculated and compared among the sites.

This cursory comparison of surface area (Figure 15) indicates that the alternative substrate reefs have the highest surface areas followed by the shell piles and the reefball sites. Once planted with a veneer of shell and hatchery spat-on-shell the alternative substrate reefs should enhance the ecological value of the shoal for oysters, other sessile organisms, and resident and transient fish species.

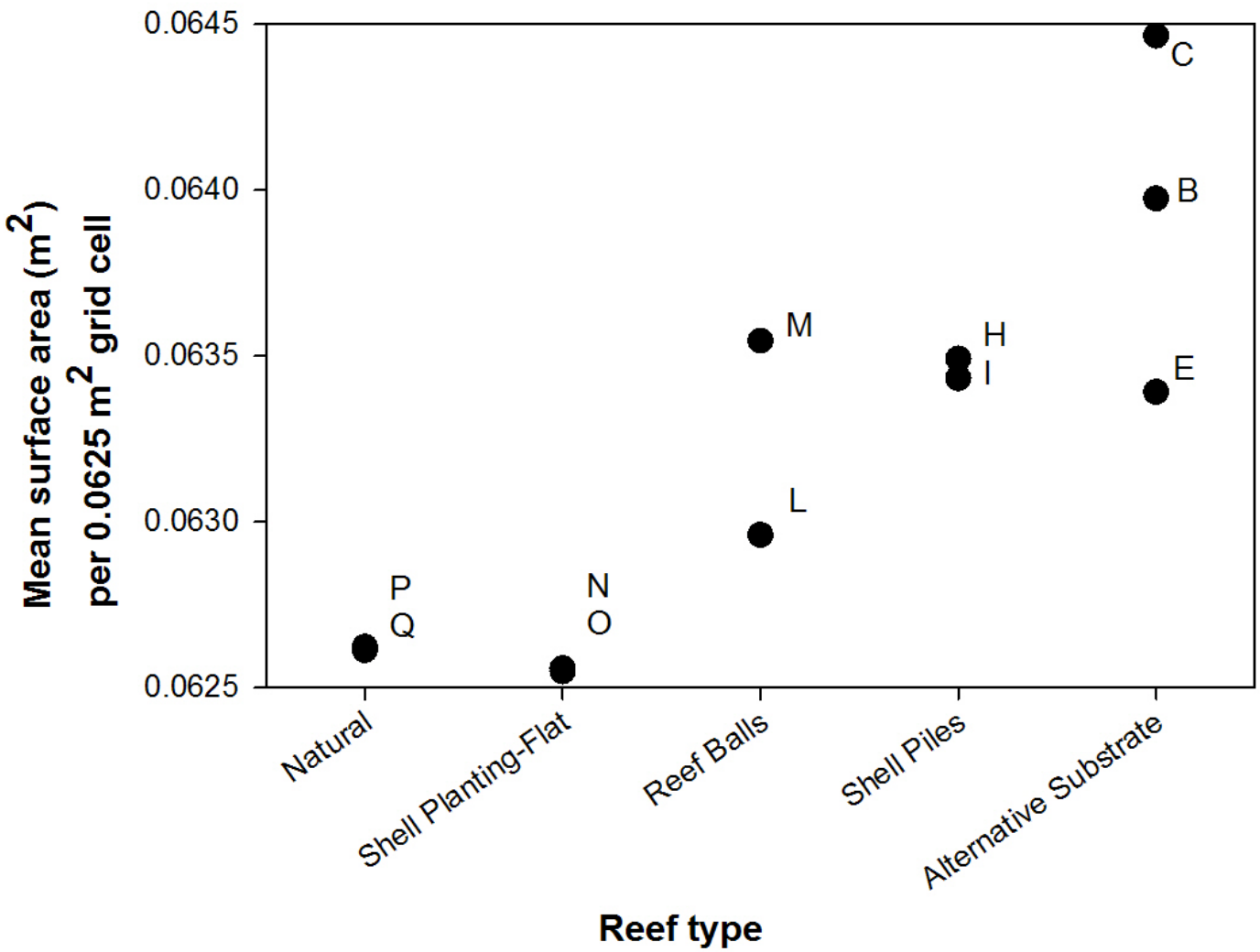

Figure 15. Surface area, calculated from 0.5 acre bathymetry grids, is compared among different oyster reef types; letters identify the sites in Figure 3. A surface area value of 0.0625 m^2 is that of a flat surface.

Benthic Habitat- Acoustic backscatter was extracted from the sonar record to identify the distribution of hard and soft sediments (Figure 16). Although the available native pixel resolution is not as high as sidescan sonar, backscatter provides a product free of some sidescan sonar acquisition artifacts. Backscatter complements bathymetry by defining the geometry and relative hardness of features associated with the main shoal. Video camera drops and Ponar grab samples (Figure 16) suggest that the shell piles and flat shell plantings on the main shoal are relatively free of sediment but that the patchy natural oyster habitat surrounding the shoal is heavily sedimented. Presumably, sedimentation of natural patch reef is greatest in areas of lower relief.

Backscatter, ground validation (Figure 16), and data from the earlier MGS survey were used to characterize benthic habitat within the survey extent and create habitat polygons. Figure 17 and Table 1 illustrate and summarize the area currently covered by various forms of reef building activities. GIS polygons, hand digitized from sonar imagery at a scale of 1:3000, indicate that the USACE alternative substrate reefs cover 34722 m^2. There is much natural oyster shell habitat in various stages of sedimentation surrounding the main shoal (Figure 17). The shoal still has a considerable area of hard sandy bottom suitable for additional reef building efforts (Table 1).

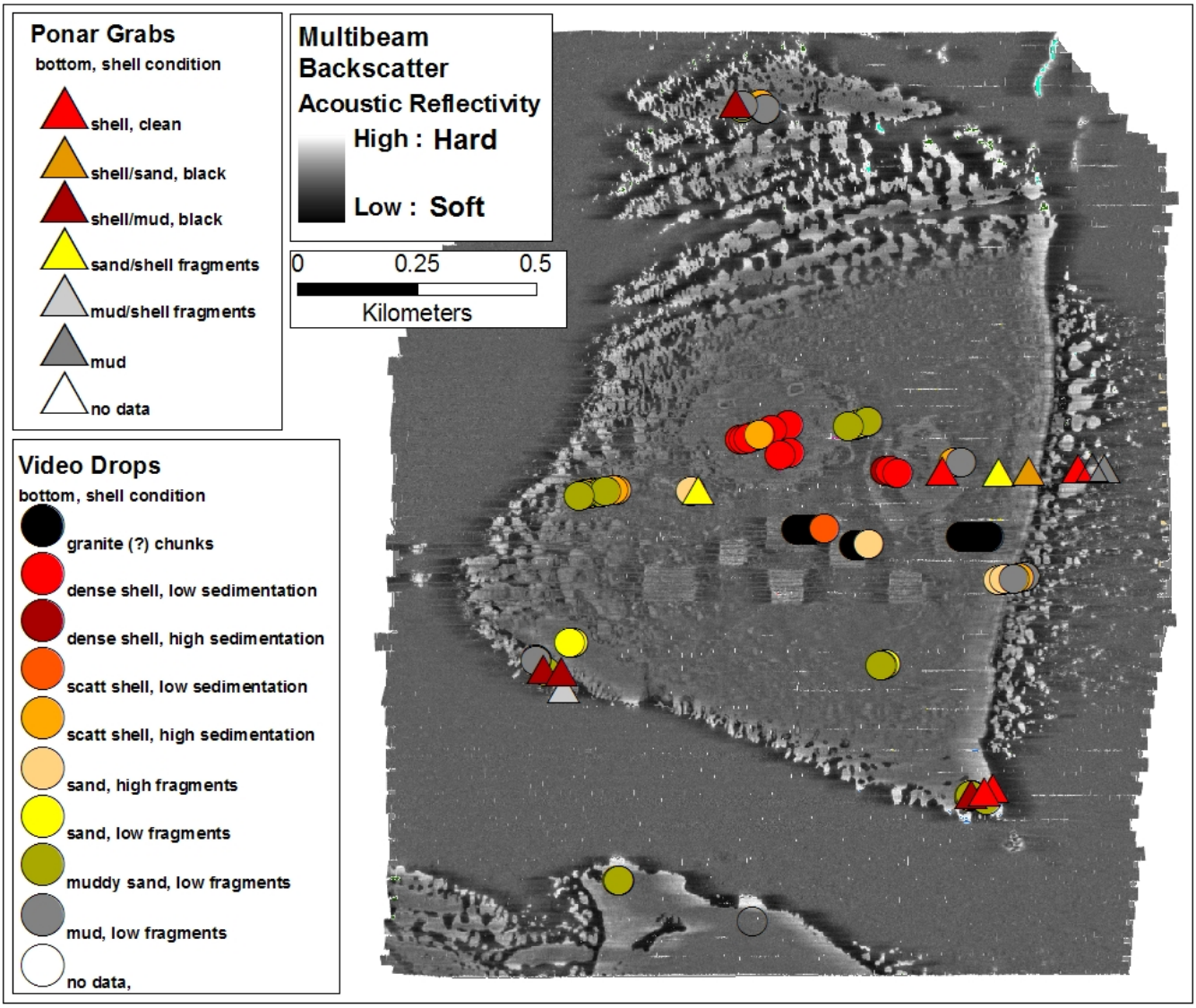

Figure 16. Acoustic backscatter and ground validation data used to create benthic habitat polygons. Shadow effects in the backscatter result from sonar system autogain settings.

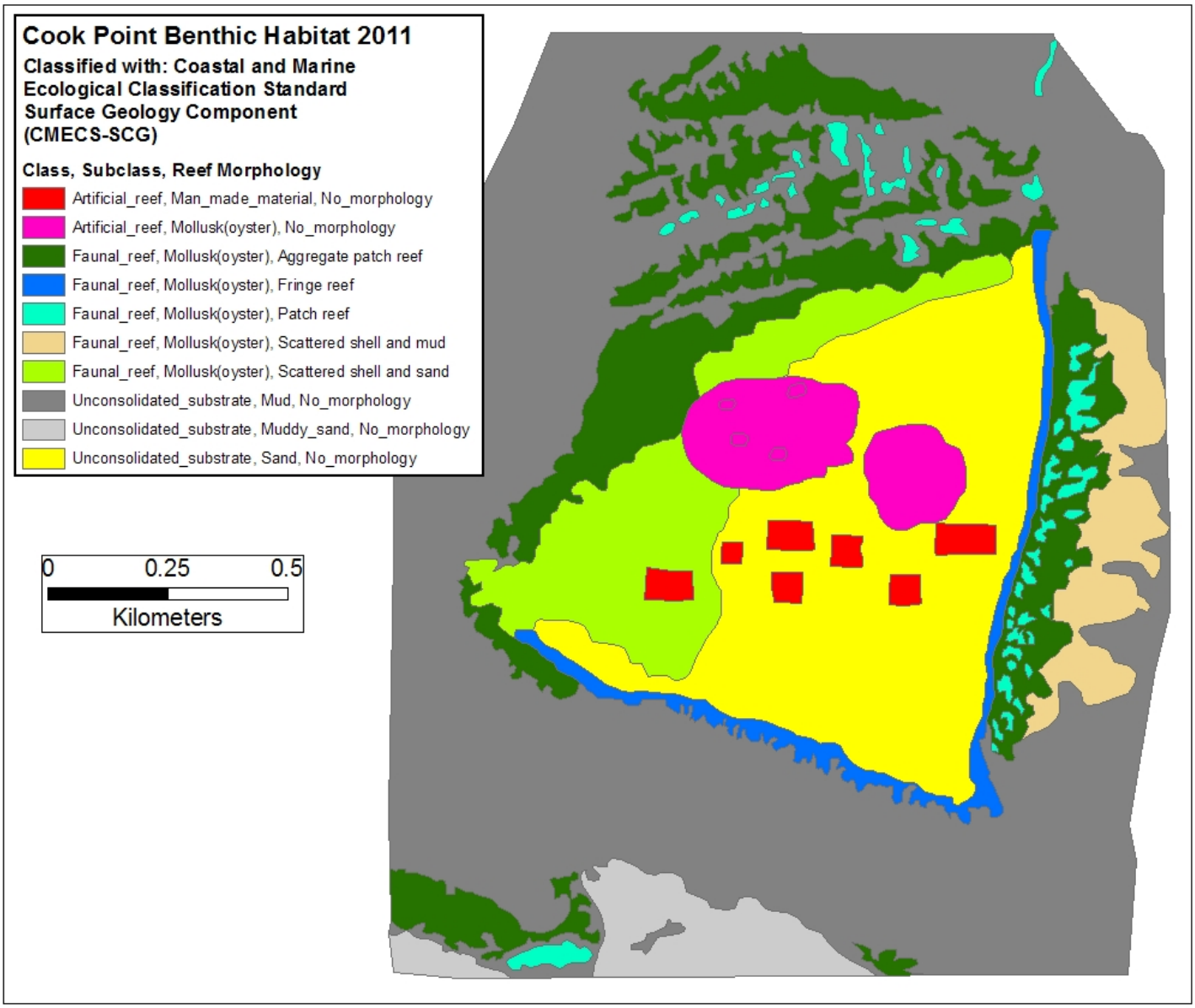

Figure 17. Benthic habitat polygons derived from acoustic backscatter and ground truthing data.

Table 1. Area summary by CMECS-SGC habitat type.

Class	Subclass	Morphology	Area (m^2)	Area (%)
Artificial_reef	Man_made_material	No_morphology	34722.2	1.2
Faunal_reef	Mollusk(oyster)	Patch	48805.2	1.6
Faunal_reef	Mollusk(oyster)	Fringe	59990.2	2.0
Unconsolidated_sediments	Muddy_sand	No_morphology	97756.0	3.3
Faunal_reef	Mollusk(oyster)	Scattered_mud	99423.1	3.3
Artificial_reef	Mollusk(oyster)	No_morphology	107695.9	3.6
Faunal_reef	Mollusk(oyster)	Scattered_sand	202931.8	6.8
Faunal_reef	Mollusk(oyster)	Aggregate_patch	414234.1	13.9
Unconsolidated_sediments	Sand	No_morphology	454929.0	15.2
Unconsolidated_sediments	Mud	No_morphology	1468942.0	49.1
		Total area =	2989429.5	

Citations

Jenness, J.S. 2004. Calculating landscape surface area from digital elevation models. Wildl. Soc. Bull. 32(3):829-839.

Pittman, S.J., et al. 2007. Predictive mapping of fish species richness across shallow water seascapes in the Caribbean. Ecological modeling 207:9-21

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This document was prepared by:

NOAA Chesapeake Bay Office
410 Severn Avenue Suite 107A
Annapolis, MD, 21403

David G. Bruce – Habitat Ecologist
410-226-5193, david.bruce@noaa.gov

Jay Lazar - Hydrographer
443-949-9319, jay.lazar@noaa.gov